# Influence of Transport on Air Quality in Richmond, Virginia

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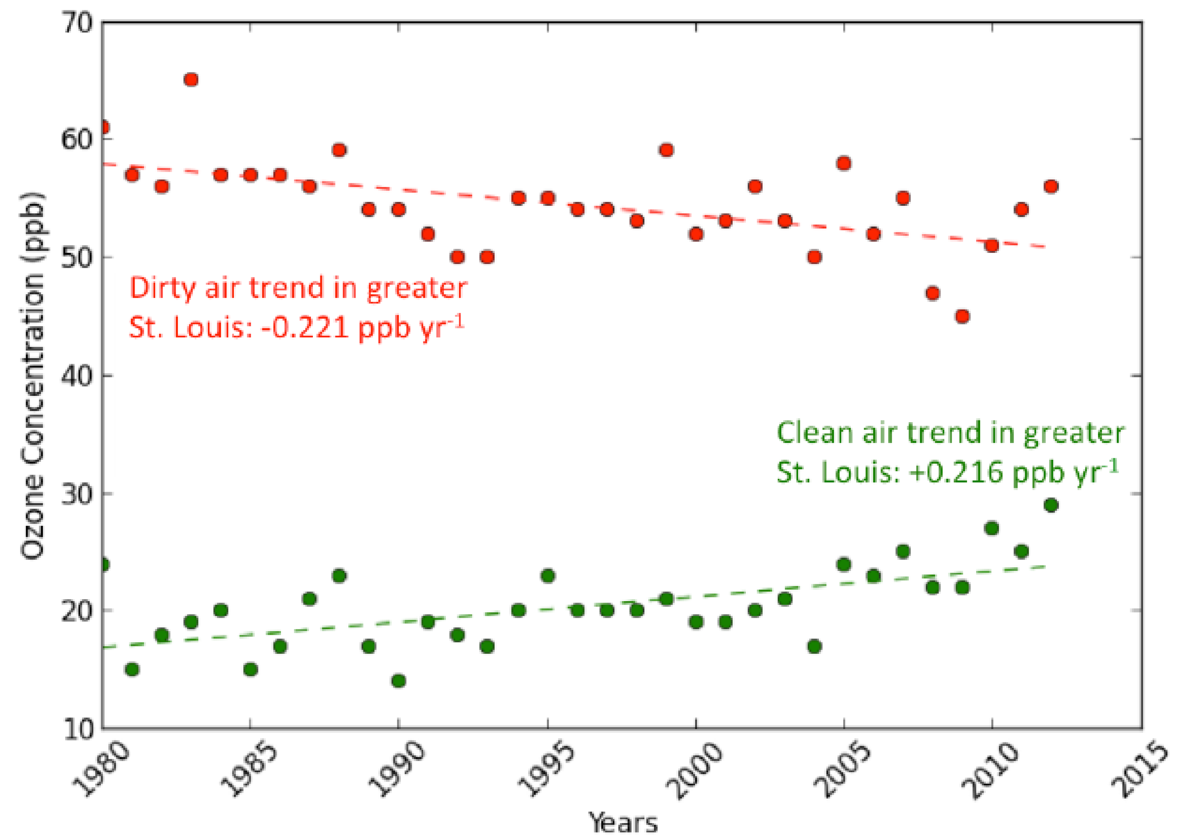
## Background

Tropospheric ozone is identified by the Environmental Protection Agency (EPA) as a criteria air contaminant, meaning that it is harmful to the public and the environment. Ozone is created via a photochemical reaction from emissions of nitrogen oxides (NOx) and volatile organic compounds (VOCs). In humans, ozone triggers numerous respiratory problems ranging from coughing and wheezing to more chronic health problems such as the development of asthma. Ozone has also been shown to be toxic to plants, with some species showing signs of damage at concentrations as low as 40 ppb.

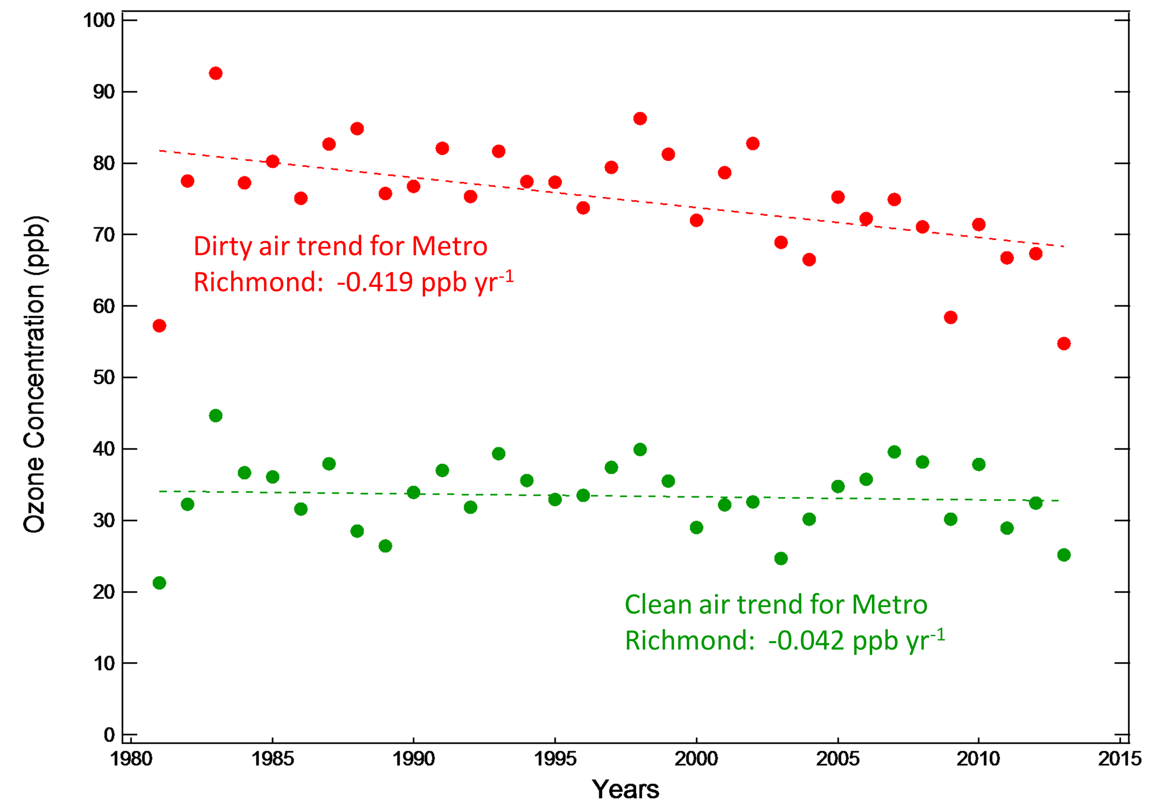
The EPA sets National Ambient Air Quality Standards (NAAQS) for all criteria pollutants identified by the Clean Air Act. An area can be designated as attainment if it meets the standard for a particular pollutant, or nonattainment if they do not meet the standard. The NAAQS for ozone has become more stringent after several revisions, and is currently at 75 ppb for an 8-hour average (EPA, 2014).

## Long-Term Ozone Trends

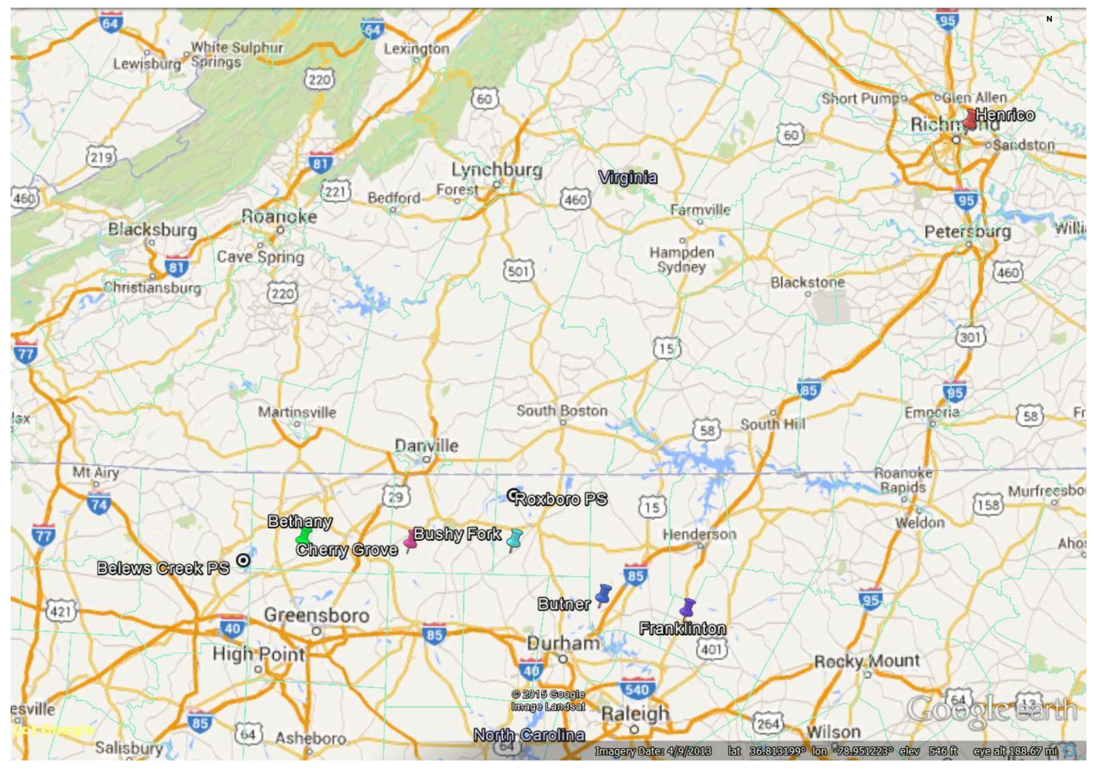
Fishman et al. (2014) analyzed ozone concentrations of air entering and exiting the St. Louis metropolitan area over 32 years. The concentration of ozone in "dirty air" leaving the city decreased considerably over that time period, but levels of ozone in "clean air" entering the city increased at a similar rate. Therefore, while St Louis may experience better air quality in terms of less extreme ozone maximums, the background levels of ozone are rising steadily.



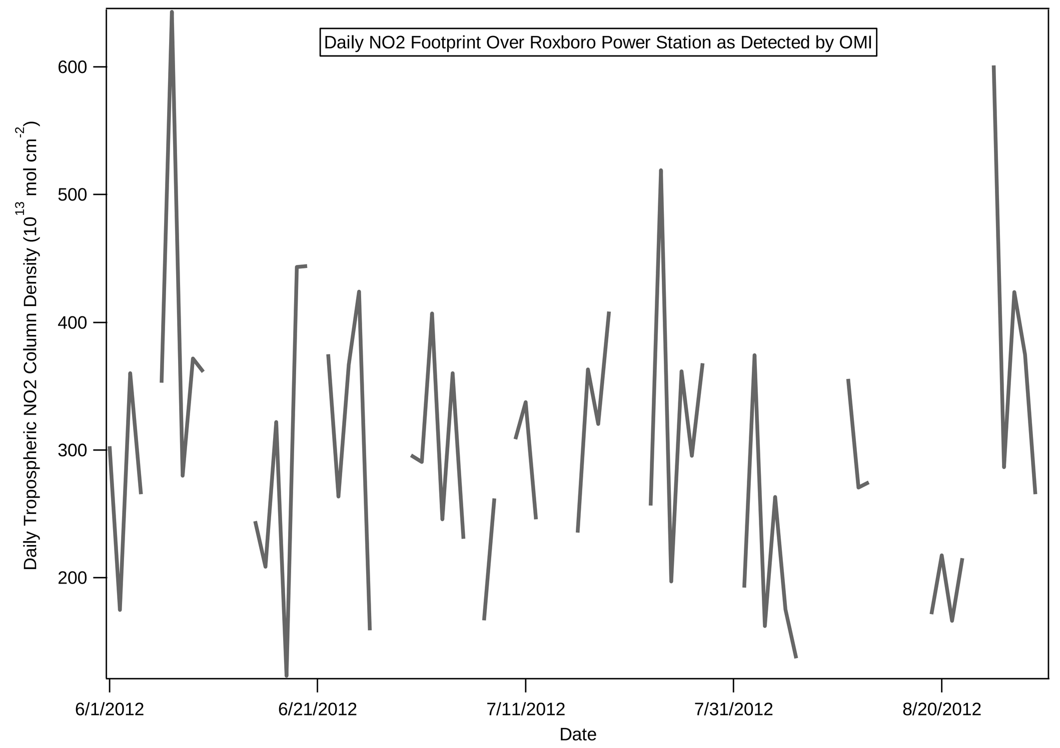

Long-term ozone concentrations were analyzed for the Richmond Metropolitan Area using 32 years of data collected from the MathScience Innovation Center located in Henrico, Virginia. "Dirty air" in Richmond has also seen a decline in ozone levels since the 1980s, but is decreasing at a rate twice as fast as St. Louis. Conversely, "clean air" in Richmond is not getting dirtier, but instead staying roughly constant over three decades. However, Richmond's mean level of background ozone is 36 ppb, roughly double that of St. Louis. Even though the St. Louis metropolitan area has more than twice the population of the Richmond area, Richmond's location east of numerous coal fired power plants may explain its higher ozone levels.



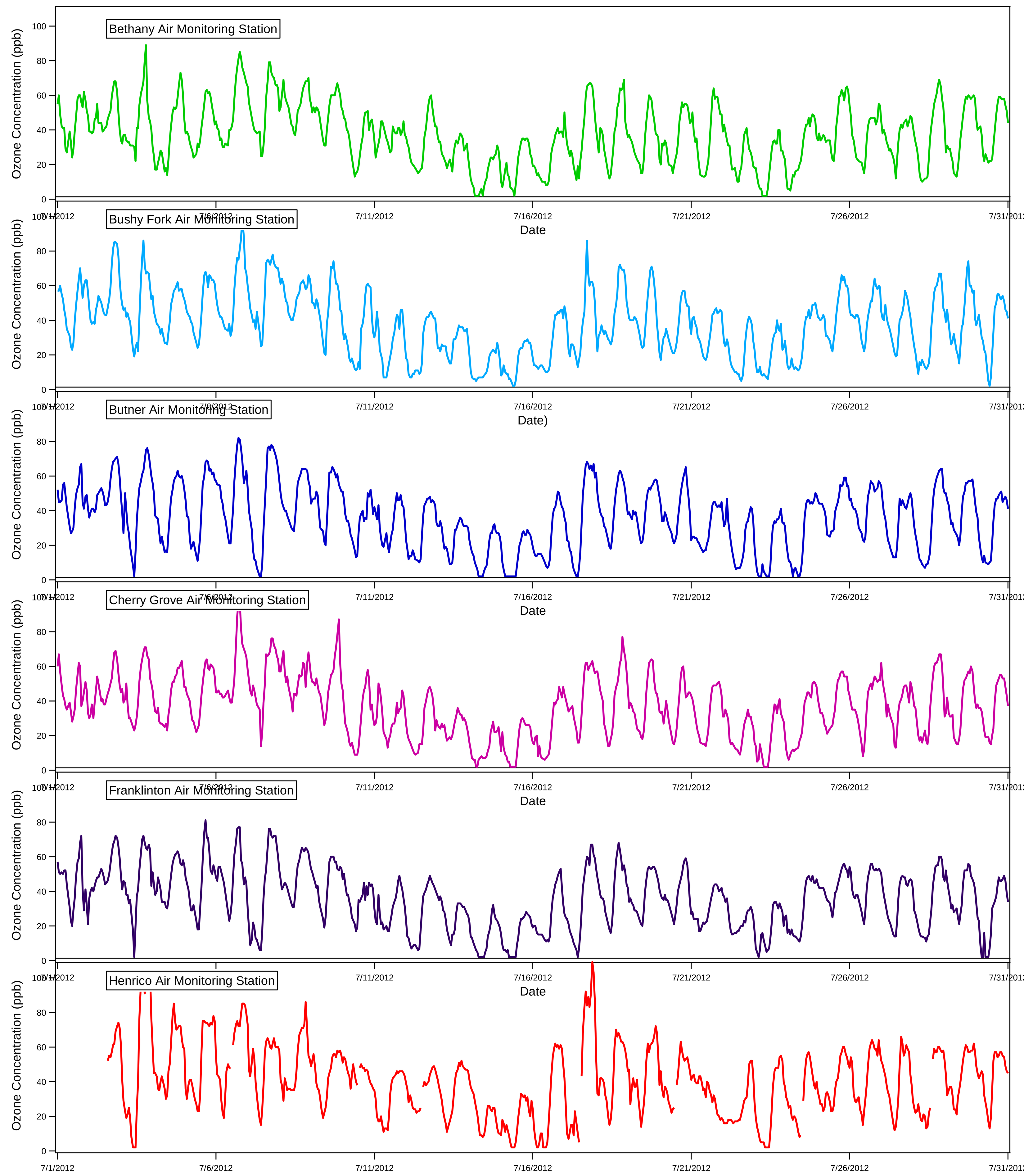

## Regional Transport



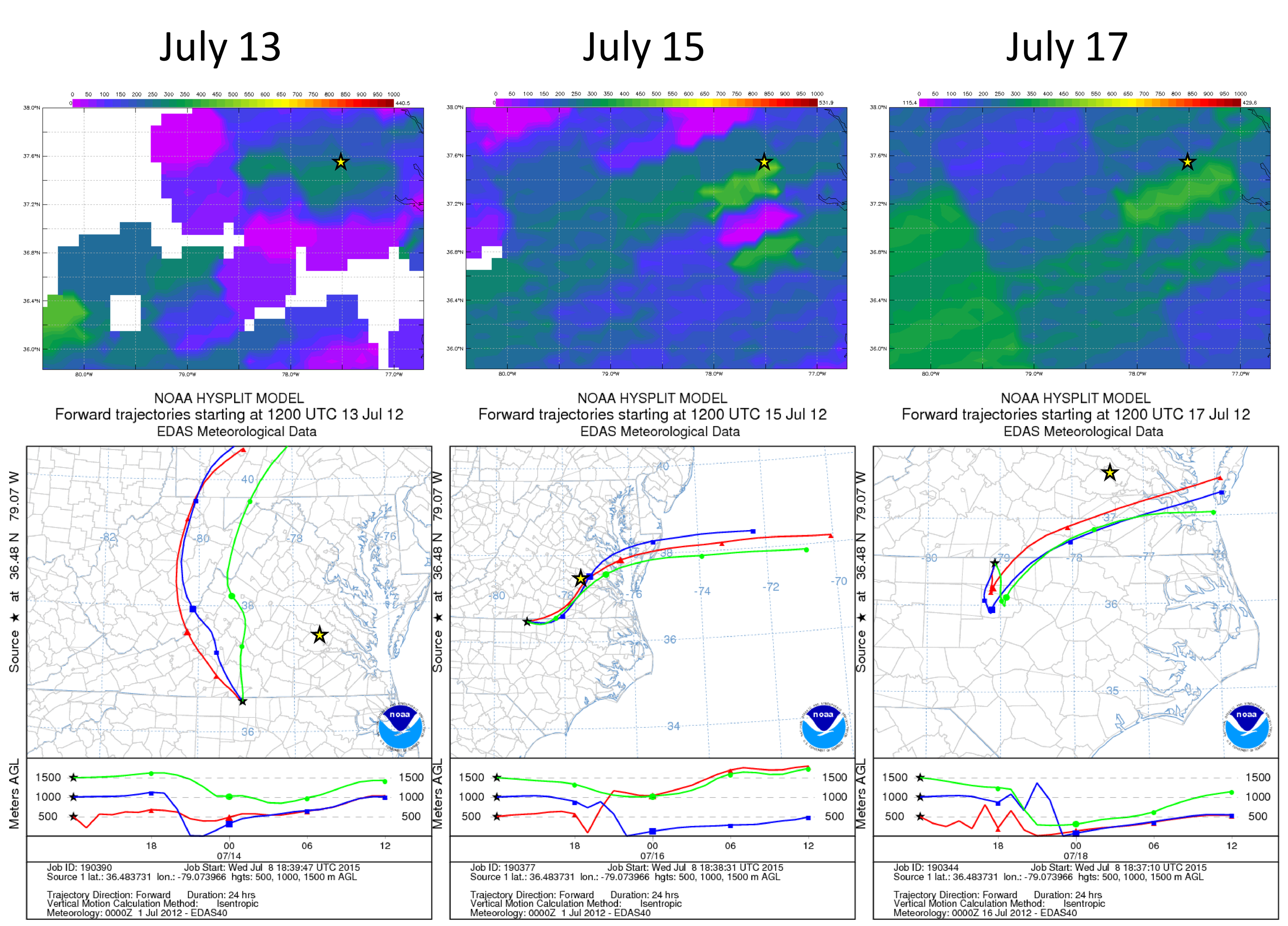
Air quality in Richmond, represented by samples collected at the monitoring station located in Henrico County, are downwind from several large coal-fired power plants. Two of these, Belews Creek Steam Station and Roxboro Steam Plant, are large, 2,000+ MW, multiunit power stations located in North Carolina (Duke Energy, 2015). Both of these power stations are listed in the top 20 of the nation's most-polluting power plants (Schneider, 2014). While there are several air monitoring stations located on the North Caroline side of the boarder, there is a notable lack on the Virginia side. Transport of any ozone precursors will have to be detected at the Henrico site. Daily NO2 soundings from the Ozone Monitoring Instrument (OMI) on the Aura satellite over Roxboro detect a consistent presence of NOx during summer months, providing ample ingredients for ozone formation in the Richmond area.




## Richmond Ozone Spike – July 16th & 17th




Ozone concentrations at all six air quality monitoring sites follow the same trend, which is to be expected as most historical ozone events in the mid-Atlantic occur over large, multi-state areas (MARAMA, 1997). On the 10th, the ozone trend begins to decline. Contributions to this may include light rain in North Carolina and strong easterly flow removing NOx from the region. By July 13th, flow was beginning to swing clockwise back towards the Richmond area. The daily overpass from OMI picks up Richmond's NOx signature, but also shows a region of extremely low NOx which disconnects Richmond from the coal plants in North Carolina. On the 14th and 15th, Richmond experiences rain heavier than the surrounding region, but cloud cover limits ozone production at all sites. NOx is however still detected by OMI on the 15th, and emissions from Roxboro arrive in Richmond on the morning of the 16th. On both the 16th and 17th, Richmond experiences higher ozone concentrations than the surrounding region, peaking at 109 ppb. OMI shows a clear pathway for NOx to travel to Richmond from Roxboro. After this sudden spike, Richmond returns to following the trend observed by the other sites in North Carolina.

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